STRAIGHT AHEAD IN MICROGRAVITY

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INTRODUCTION

This joint ESA-NASA study will address adaptive changes in spatial orientation related to the subjective straight ahead, and the use of a vibrotactile sensory aid to reduce perceptual errors. The study will be conducted before and after long-duration expeditions to the International Space Station (ISS) to examine how spatial processing of target location is altered following exposure to microgravity. This project specifically addresses the sensorimotor research gap "*What are the changes in sensorimotor function over the course of a mission*?"

METHODS

Six ISS crewmembers will be requested to participate in three preflight sessions (between 120 and 60 days prior to launch) and then three postflight sessions on R+0/1 day, R+4 ±2 days, and R+8 ±2 days. The three specific aims include: (a) fixation of actual and imagined target locations at different distances; (b) directed eye and arm movements along different spatial reference frames; and (c) the vestibulo-ocular reflex during translation motion with fixation targets at different distances. These measures will be compared between upright and tilted conditions. Measures will then be compared with and without a vibrotactile sensory aid that indicates how far one has tilted relative to the straight-ahead direction. The flight study was been approved by the medical review boards and will be implemented in the upcoming Informed Crew Briefings to solicit flight subject participation.

Preliminary data has been recorded on 6 subjects during parabolic flight to examine the spatial coding of eye movements during roll tilt relative to perceived orientations while free-floating during the microgravity phase of parabolic flight or during head tilt in normal gravity. Binocular videographic recordings obtained in darkness allowed us to quantify the mean deviations in gaze trajectories along both horizontal and vertical coordinates relative to the aircraft and head orientations. During some parabolas, a vibrotactile sensory aid provided feedback of body orientation relative to the plane coordinates.

RESULTS

Both variability and curvature of gaze trajectories increased during roll tilt compared to the upright position. The saccades were less accurate during parabolic flight compared to measurements obtained in normal gravity. Although subjects were instructed to look off in the distance while performing the eye movements, fixation distance varied with vertical gaze direction independent of whether the saccades were made along perceived aircraft or head orientations. The increased errors in gaze trajectories along both perceived orientations during microgravity can be attributed to the otolith's role in spatial coding of eye movements.

DISCUSSION

A change in an individual's egocentric reference might have negative consequences on evaluating the direction of an approaching object or on the accuracy of reaching movements or locomotion. Consequently, investigating how microgravity affects the target location will have theoretical, operational and even clinical implications for future space exploration missions. The use of vibrotactile feedback as a sensorimotor countermeasure is applicable to balance therapy applications for vestibular loss patients and the elderly to mitigate risks due to loss of orientation.

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